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Case report

Occipital condyle fracture: An unusual airbag injury

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Abstract

The installation of airbags in motor vehicles, in association with the use of seat belts, has reduced the incidence of head injuries, as well as significantly decreasing morbidity and mortality in motor vehicle accidents. Nevertheless, the literature on the subject increasingly refers to lesions related to airbag deployment. These are usually minor, but in certain circumstances, severe and fatal injuries can result. This is a case report of serious injury due to airbag deployment, involving a restrained driver who suffered occipital condylar injury when his airbag deployed in a frontal collision. The range of airbag associated injuries is reported and predisposing factors, such as the probable proximity to the airbag housing, is discussed.

Keywords: Airbag; Motor vehicle crash; Head injuries; Seat belt mark

1. Introduction

The introduction of airbags has led to a significant reduction in morbidity and mortality from road traffic accidents. Together with the three-point lap-shoulder seat belt, it improves the level of protection for the driver in the event of a frontal collision. An airbag is intended to be a supplemental safety device. However, the airbag, like the seat belt, produces its own range of injuries. Although injuries related to airbag deployment have been reported in all areas of the body, facial injuries are by far the most common. Several cases have been reported, especially ocular, facial soft tissue and periorbital structure trauma and temporomandibular joint injuries.

Airbags are triggered by frontal or fronto-angular crashes, which comprise approximately 65% of fatalities in motor vehicle accidents. A sudden deceleration in speed of approximately 32 km/h (20 miles/h) is detected by a crash sensor. This device ignites a charge of sodium azide, which produces a large volume of nitrogen gas, inflating the airbag up to a volume of 40 L (Eurobag design) or 70 L (full size) within 10 ms. Although airbags usually deploy at speeds of 170–330 km/h (110–210 mph), following sudden deceleration, the actual velocity at face contact is much slower. Airbags begin to deflate in about 0.2 s following impact.[1]

Few data are available to date on the problems occuring during atypical collisions and when the driver is not in the intended optimal driving position. We report a case in which the collision dynamics probably resulted from the driver being in close proximity to the steering column at the time of deployment of the airbag. This is an interesting analysis and important interpretation of the mechanism of injury related to airbag deployment, which is particularly crucial in the field of Forensic Pathology and Legal Medicine.

2. Case presentation

A 46-year-old man, of short stature (172 cm), was driving on a motorway in a 1996 model Mercedes 300 CE, fitted with an airbag; he had a head rest which was

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Fig. 1. Frontal view demonstrating asymmetry of the face and the seat belt mark on the left shoulder.

appropriately adjusted and he was wearing a standard three-point seat belt. Suddenly, he lost the control of the car and was involved in a head-on collision with a tree.

He reported being thrown backwards in his seat and then forward nearer to the steering wheel. The vehicle impacted so heavily into the tree that the airbag was immediately deployed. He reported preferring to sit much closer to the steering wheel than most drivers, so at the time of inflation of the airbag, his face was much nearer the steering wheel than the normal driving position.

He reported being conscious the entire time.

The local emergency department was called by another driver, an ambulance picked him up and, on arrival in the emergency department, he complained of facial pain, some neck discomfort and a laceration on the anterior surface of his left shoulder. This last lesion was consistent with a seat belt mark (Fig. 1 and Fig. 2). No major facial bruising was detected, but there was clear facial asymmetry associated with exophthalmus (Fig. 4) and some tenderness on the back of his neck.

X-rays of the cervical spine and chest showed no evidence of bony injuries. A CT revealed a severe fracture of the left orbito-zygomatic-maxillary complex (Fig. 3). These multiple skeletal injuries were suspected on the basis of the physical examination described above.

The CT also demonstrated a right condyle fracture of the occipital bone (Fig. 5); the involvement of occipital bone explained the patient's neck discomfort.

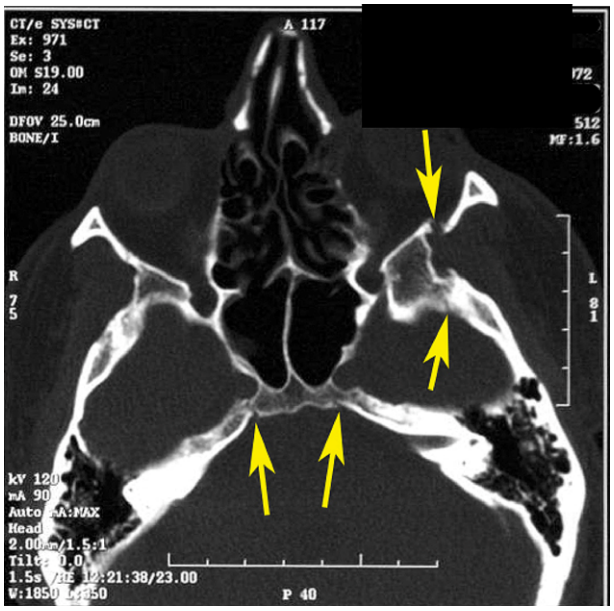

Fig. 3. CT imaging showing the fracture of left orbito-zygomatic-maxillary complex, involving also the maxillary sinus (arrows), and the right orbital floor fracture (arrow).

Fig. 2. Close-up of the seat belt mark.

Fig. 4. Close-up of the face showing clear asymmetry.

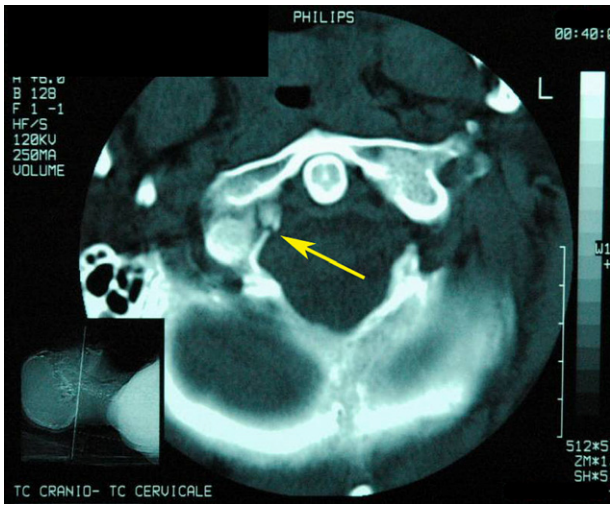

Fig. 5. CT imaging showing the right occipital condyle fracture (arrow).

3. Discussion

The introduction of seat belts and the installation of airbags in motor vehicles as passive safety devices, have contributed to reducing the severity of injuries following motor vehicle accidents. The airbag, in particular, has reduced morbidity and mortality, including brain injury, associated with such accidents, by as much as 25%.[2]

However, severe injuries continue to be sustained in frontal or fronto-angular crashes in spite of the introduction of airbags.[3] Interestingly, with the increasing prevalence of airbags in North America, reports discussing injuries related to airbag deployment began to appear in medical literature in the early 1990s.[4]

Most of the more serious injuries are caused by the act of deployment and are secondary to the shearing forces produced by the "punch-out" of the bag.[5,6] An unrestrained driver accelerating towards the airbag suffers flexion of the upper spine, receiving a blunt impact to the chest area. However, in the case of a restrained driver, an airbag inflates upward, hyperextending the cervical spine. In this case, the chin, neck and face area receive the maximum impact of the airbag.[7]

Nonetheless, the most commonly observed injuries are minor bruises and abrasions, mainly to the face, neck and upper limbs.[8]

In the study conducted by Simoni et al., nasal fractures were the most common facial fractures at 50%, with zygomaticomaxillary complex (ZMC) fractures second at 46%. Mandibular fractures were the least common (27%). Use of restraining devices was found to affect only the pattern of ZMC fractures. In patients presenting facial fractures, the use of seat belts alone decreased the chance of ZMC fractures from 49% (no restraints) to 37%. Interestingly, 45% of patients presenting facial fractures due to airbag deployment had ZMC fractures. The study demonstrated that airbags, especially if used in conjunction with seat belts, greatly reduce the incidence of facial fractures. However, if a crash is severe enough to cause facial fractures, airbags do not change the pattern of facial fractures significantly and ZMC remains the main fracture encountered.[9]

The eye may be injured by the fully deployed airbag, causing corneal abrasion but more serious injuries, such as retinal detachment and orbital blow-out fractures, can also be sustained from an actively deploying airbag.[10,11] Superficial burns of the upper extremities, face and neck are well documented.[12,13]

Temporary hearing impairment and tinnitus have been reported on a number of occasions.[14,15]

Upper limb injuries occur due to the proximity of the forearms to the deploying airbag and are caused either by direct contact with the activated airbag or by flinging the limb against the interior structure of the car.[16,17]

Minor chest injuries and rib fractures have been reported and more serious thoracic injuries have occured in comparatively low velocity crashes.

Airbag function is known to be more effective when used in conjunction with three-point seat belts, leading to a reduction in fatality by more than 45% (18% with airbag alone), and also if the driver is at the right distance from the steering wheel (a minimum gap of 25 cm between the steering wheel and the driver's sternum is advised).[8,19] When an adult driver or passenger is in an atypical position, there is a change in the pattern of deployment of the airbag.[20] In this case, rather than preventing injury, the airbag can cause injury. This occurs primarily when the occupant is in the "deployment zone" of the airbag. Specifically, if the occupant is too near the steering wheel, the lower part of the expanding airbag is restricted by the chest, leading not only to excessive forces being applied to the thorax, but also to a greater upward expansion of the bag. This, in turn, creates stronger shearing forces on the skin of the neck and face, which may be responsible for the abrasions noted in many patients and may be the reason for the associated hyperextension of the neck.[5–20]

In fact, it has also been shown in animal experiments that the rapid deployment of the airbag causes complex biomechanical forces between the head, neck and torso and also within the chest.

Basilar skull fracture, as seen in our patient, may not be uncommon in this context and this is illustrated by a recent report from Denmark of two similar cases. [21] However, in both these cases, the drivers were unbelted. Our patient was wearing a seat belt, but the probable incorrect seating position, placing him too close to the expanding airbag, was probably responsible for the pattern of injury seen. This interpretation is helpful, especially in the field of Forensic Pathology and Legal Medicine, where experts are frequently consulted to formulate a judgement about the possible causes of a particular lesion. In order to reach an exact interpretation of the anatomical signs of a lesion, a correct and accurate evaluation of the mechanism of the injury is crucial.

4. Conclusion

The reduction in morbidity and mortality since airbags became widely available in new vehicles is well established. This report highlights the need to be aware of potential hazards associated with their use. Most airbag related adult severe head injuries are preventable if the occupants use seat belts and keep at least a 25 cm distance between the airbag cover and the front of their chest. The vast majority of drivers should be able to maintain this distance. Drivers and passengers who are unable to maintain the recommended distance from the airbag cover should consult vehicle manufacturers about potential solutions, including the disabling of the airbag mechanism.

An understanding of the role of correct driver and passenger positioning in cars equipped with airbags is crucial to the correct interpretation of the signs and symptoms of lesions correlated to airbag deployment.

References

1. Graham JD, Thompson KM, Goldie SJ, Segui-Gomex M, Heinstein M. The cost-effectiveness of air bags by seating position. *JAMA* 1997;**278**:1418.
2. Jagger J, Vernberg D, Jane JA. Airbags: reducing the toll of brain trauma. *Neurosurgery* 1987;**20**:815.
3. Roccia F, Servadio F, Gerbino G. Maxillofacial fractures following airbag deployment. *J Cranio Maxill Surg* 1999;**27**:335–8.
4. Larkin GL. Airbag-mediated corneal injury. *Am J Emerg Med* 1991;**9**:444–6.
5. Lau IV, Horsch JD, Viano DC. Mechanism of injury from air bag deployment loads. *Accid Anal Prev* 1993;**25**:29–45.
6. Maxeiner H, Hahn M. Airbag- induced lethal cervical trauma. *J Trauma* 1997;**42**:1148–51.
7. Blacksin MF. Patterns of fracture after airbag deployment. *J Trauma* 1993;**35**:840–3.
8. Antosia RE, Partridge RA, Virk AS. Air bag safety. *Ann Emerg Med* 1995;**25**:794–8.
9. Simoni P, Ostendorf R, Cox III AJ. Effect of air bags and restraining devices on the pattern of facial fractures in motor vehicle crashes. *Arch Facial Plast Surg* 2003;**5**:113–5.
10. Cacciatori M, Bell RW, Habib NE. Blow-out fracture of the orbit associated with inflation of an airbag: a case report. *Br J Oral Maxill Surg* 1997;**35**:241–2.
11. O'Halloran HS, Draud K, Stevens JL. Primary enucleation as a consequence of airbag injury. *J Trauma* 1998;**44**:1090.
12. Hallock GG. Mechanisms of burn injury secondary to airbag deployment. *Ann Plast Surg* 1997;**39**:111–3.
13. Baruchin AM, Jakim I, Rosenberg L. On burn injuries related to airbag deployment. *Burns* 1999;**25**:49–52.
14. Buckley G, Setchfield N, Frampton R. Two cases of possible noise trauma after inflation of airbags in low speed car crashes. *BMJ* 1999;**318**:499–500.
15. Saunders JE, Slattery WH, Luxford WM. Automobile airbag impulse noise: otologic symptoms in six patients. *Otolaryng Head Neck Surg* 1998;**118**:228–34.
16. Huelke DF, Moore JL, Compton TW. Upper extremity injuries related to airbag deployments. *J Trauma* 1995;**38**:482–8.
17. Marco F, Garcia-Lopez A, Leon C. Bilateral Smith fracture of the radium caused by airbag deployment. *J Trauma* 1996;**40**:663–4.
18. Viano DC. Restraint effectiveness, availability and use in fatal crashes. Implications in injury control. *J Trauma* 1995;**38**:538.
19. Loo GT, Siegel JH, Dischinger PC, Rixen D, Burgess AR, Addis MD, et al. Airbag protection versus compartment intrusion effect determines the pattern of injuries in multiple trauma motor vehicle crashes. *J Trauma* 1996;**41**. 935.
20. Walter DP, James MR. An unusual mechanism of airbag injury. *Injury* 1996;**27**:523–4.
21. Hansen TP, Nielsen AL, Thomsen TK. Avulsion of the occipital bone – an airbag specific injury. *Lancet* 1999;**353**:1409–10.